16164

Development of TOSOM Threat Trees

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TOSOM = Threat oriented Survivability Optimization Model

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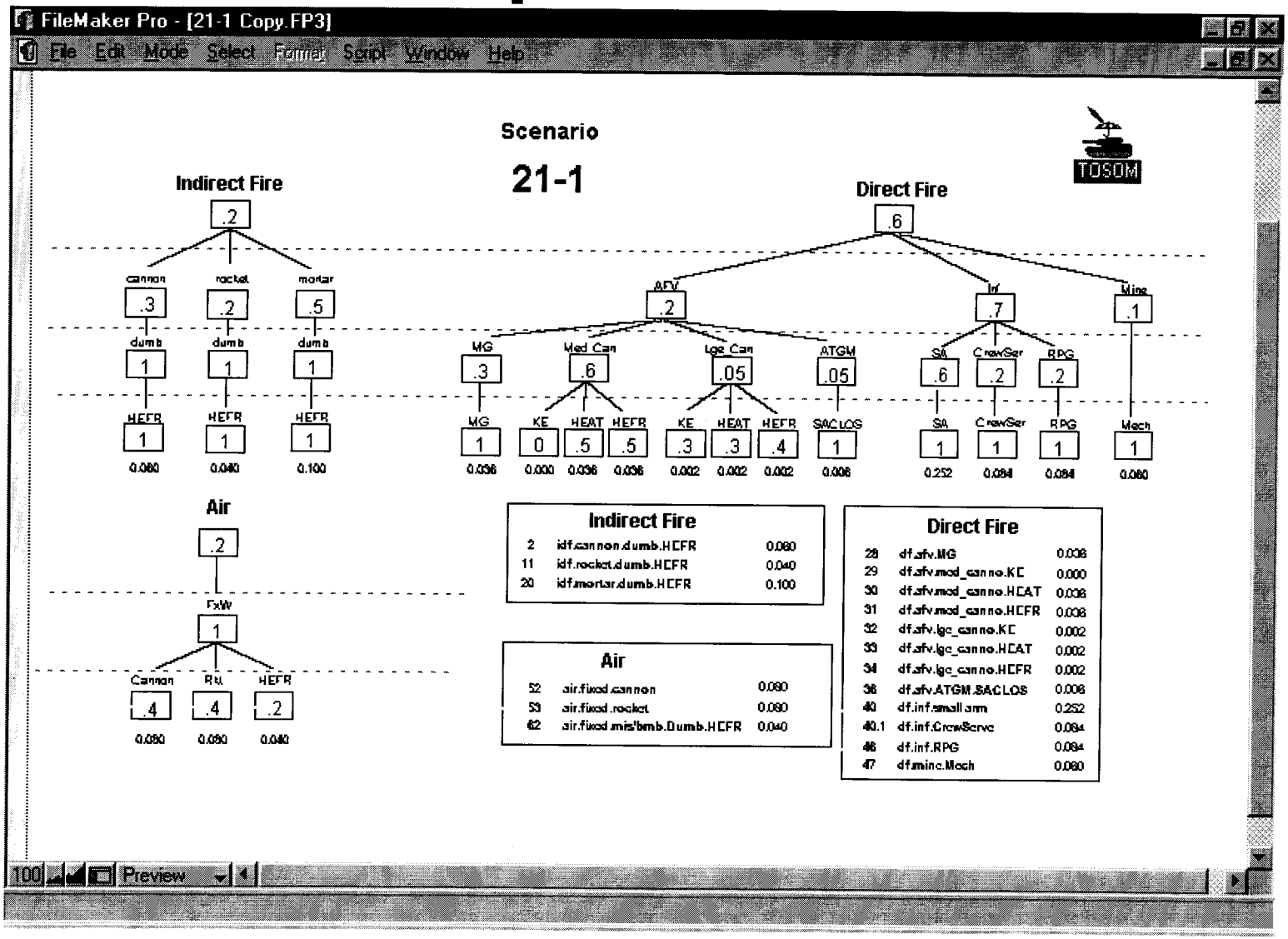
What is TOSOM?

- TOSOM = **T**hreat **O**riented **S**urvivability **O**ptimization **M**odel.
- PC Based Decision Support Tool developed for TARDEC.
- Designed as a front-end "filter" to help the analyst select survivability enhancements.
- Used to support, among others, the Crusader, RST-V, AAAV and LAV programs.

What are Threat Trees?

- Representations of possible threat environments for specific vehicle systems.
- Assumes an encounter will take place - weights the likelihood of specific encounters under predicted conditions.
- Output is the weighted expected likelihood of system loss.

Example Threat Tree



Then What?

- Compare the available or projected countermeasures (with their associated predicted effectiveness against the various identified threats) and the vehicle "budgets" ($'s, space claim, weight, etc.)
- Generate a list of possible countermeasure suites with associated predicted effectiveness and costs.

Back to the Focus of this Paper - development of the Threat Trees!

- THE MAJOR ISSUE - DATA! What do I need and how do I get it?
- Encounter Data
- Consequence Data
  - Probability of Trigger Pull
  - Probability of Hit (P_h)
  - Probability of Kill (P_k)

TOSOM Threat Data Review

Population DATA

Threat Encounter Distribution
-type
-frequency

Scenario and Assessment Driven

Performance DATA

Probability of Acquisition

Probability of Hit

Probability of Kill

Sensor and Weapon Driven

Data Assumptions

- Data from previous studies, (originally from AMSAA), is acceptable
- Using surrogates for unavailable weapons, (documented), is acceptable
- Indirect fire weapon aiming errors and mission profiles are constant through out vignette(s)
- Use of performance data extracted from existing approved models is acceptable

Encounters

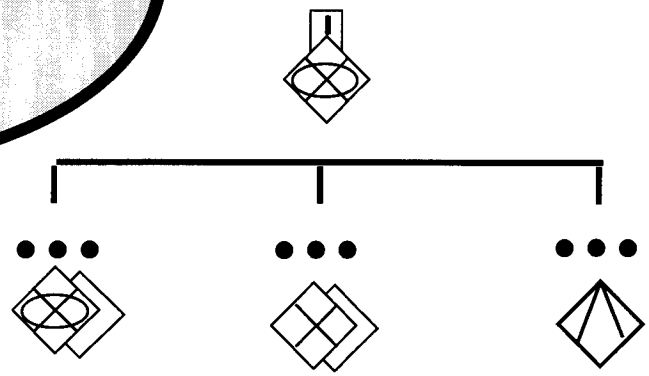
TOSOM works under the assumption that a single encounter occurs. An encounter is defined as a "survivability event" - an event that has the potential of disabling or destroying the vehicle. It is not necessarily a single round or munition. Given an encounter, what was it with?

Scenarios and Vignettes

- Scenarios and Vignettes provide the level of detail needed to support use of models and simulations to conduct...weapon systems analyses.
- Using existing scenarios provides an environment where threat distribution can easily be determined and where the operational context can be derived.

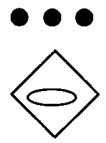
Example Scenario

Red TO / Capabilities
Non-Enhanced DPG



3 IFV	2 RPOA	6 Towed 100mm
4 82 MM Mort	1 MANPAD	7 MTLBT Prime Mover
2 RPOA	3 RPG7	1 SPT Truck
1 MANPAD	24 AK-47	1 Cargo Trailer
3 RPG 7	2 SVD	1 GSR
24 AK-47	3 RPK-74	2 Laser Rangefinder
1 SVD		6 RPG
3 RPK-74		8 9mm PM
		44 Ak-47
		52 personnel

Supporting Assets



X 2

3 TANKS

EN Effort

Prepared Defense / Positions
3x Decoys
Obstacles prepared for Emplacement

Example of Data Base Table

Index	Category	Wpn Description	Database Wpn Used	Averaged Result
2	idf.cannon.dumb.HEFR	2S1 122mm How w/HEFR WAC-21 155mm How w/HEFR D-20 152mm How w/HEFR M-46 130mm Gun w/HEFR D-30 122mm How w/HEFR	OF-24/122mm vs. LAV 155 HOW/HE vs. LAV MAS-D/152mm vs. LAV ER-428/130mm vs. LAV OF-24/122mm vs. LAV	.116
31	df-afv-mdc-HEFR	B-10 82 mm RCLG w/HEAT BMP-2 30mm HE Frag PT-76 w/76 mm HEAT	BK-881m (82mm HE) vs LAV BMP2 30 mm vs AAAV SPG-9 vs. M113 PG-15P (73mm HE) vs LAV	.318

Threat Performance Analysis

- Probability of Acquisition (RSTA)
  - Detect
  - Recognize
  - Identify

- Probability of Hit/Kill
  - Attack Angle Distributions
  - Range Distributions
  - Data Mining

Probability of Trigger Pull (P_{tp})

- This is sort of a rolled up probability of detection /recognition /classification /identification, etc. The probability that a threat will obtain enough information to take a shot at our vehicle.
- For the base (untreated) case, assume P_{tp} = 1.0. Treatments/countermeasures may degrade this value.

P_h

- Can be developed using CASTFOREM routines.
- Direct Fire - Some already exist, others generated using vehicle dimensions.
- Indirect Fire - HE & DPICM can extracted from CASTFOREM.
- Indirect Smart - developed from MLP Data from PM-GSI program.

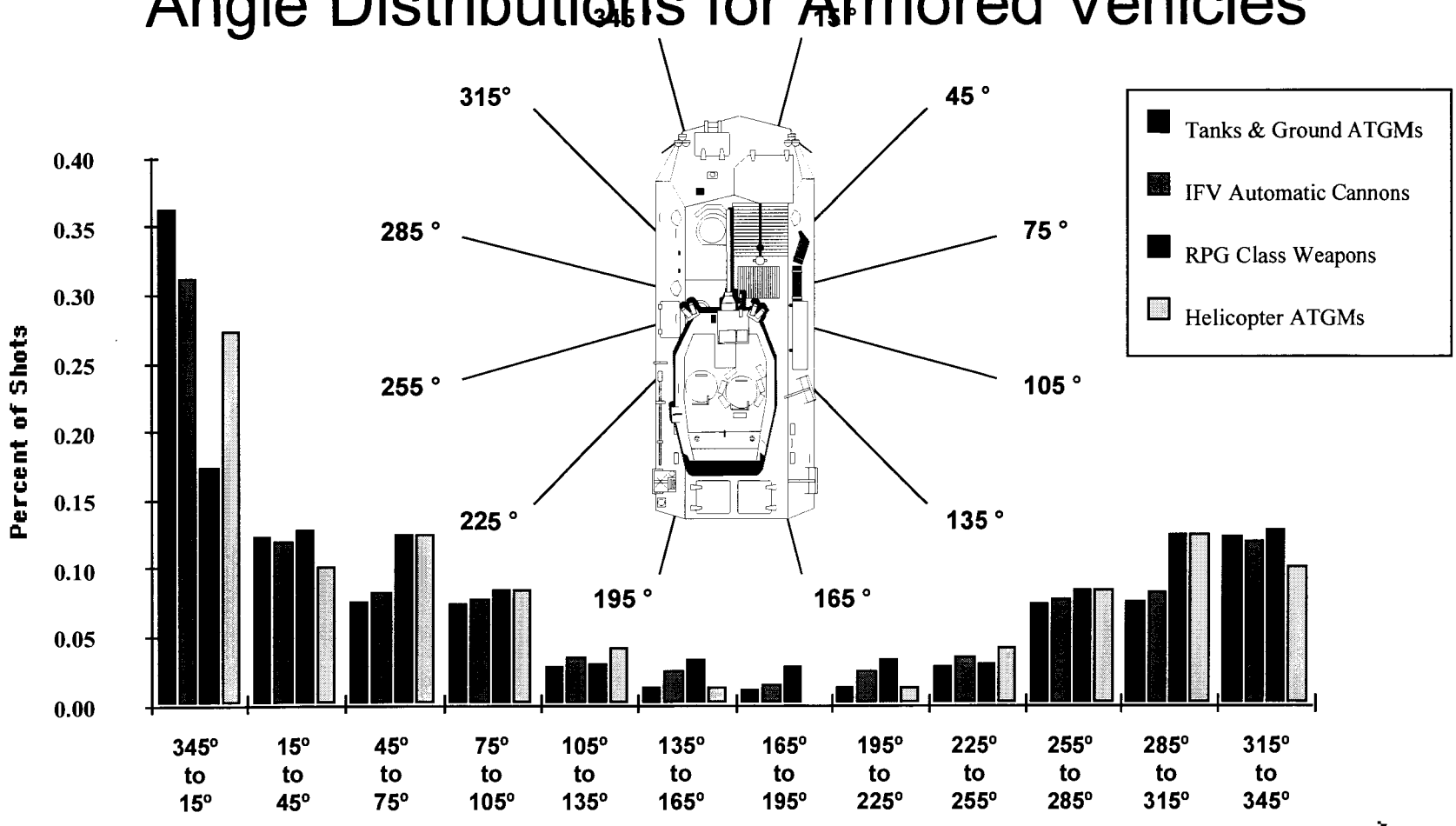
CASTFOREM P_h Tables

Range	Exposure HD = 1 FE = 2	Firer Motion S=1 M=2	Target Motion S=1 M=2	0Þ	30Þ	60Þ	90Þ	120Þ	150Þ	180Þ
500	1	1	1	0.787	0.816	0.817	0.811	0.817	0.816	0.787
500	1	1	2	0.888	0.895	0.895	0.895	0.895	0.895	0.888
500	1	2	1	0.761	0.795	0.797	0.788	0.797	0.795	0.761
500	1	2	2	0.848	0.862	0.862	0.860	0.862	0.862	0.848
500	2	1	1	0.942	0.964	0.965	0.96	0.965	0.964	0.942
500	2	1	2	0.989	0.994	0.994	0.994	0.994	0.994	0.989
500	2	2	1	0.921	0.949	0.95	0.944	0.95	0.949	0.921
500	2	2	2	0.973	0.983	0.983	0.981	0.983	0.983	0.973
625	1	1	1	0.739	0.783	0.785	0.773	0.785	0.783	0.739
625	1	1	2	0.815	0.841	0.842	0.837	0.842	0.841	0.815
625	1	2	1	0.707	0.758	0.761	0.746	0.761	0.758	0.707
625	1	2	2	0.77	0.806	0.807	0.798	0.807	0.806	0.77
625	2	1	1	0.905	0.941	0.943	0.933	0.943	0.941	0.905
625	2	1	2	0.958	0.977	0.977	0.974	0.977	0.977	0.958
625	2	2	1	0.874	0.918	0.921	0.908	0.921	0.918	0.874
625	2	2	2	0.926	0.954	0.955	0.948	0.955	0.954	0.926
750	1	1	1	0.694	0.751	0.755	0.736	0.755	0.751	0.694
750	1	1	2	0.742	0.792	0.795	0.78	0.795	0.792	0.742

Engagement Range Distributions

- Driven by (among other factors) Threat Sensor and Weapon performance.
- Models tend to engage at maximum range
- Estimates may be necessary.

DUSA(OR) Approved Horizontal Attack Angle Distributions for Armored Vehicles



TOSOM

P_k

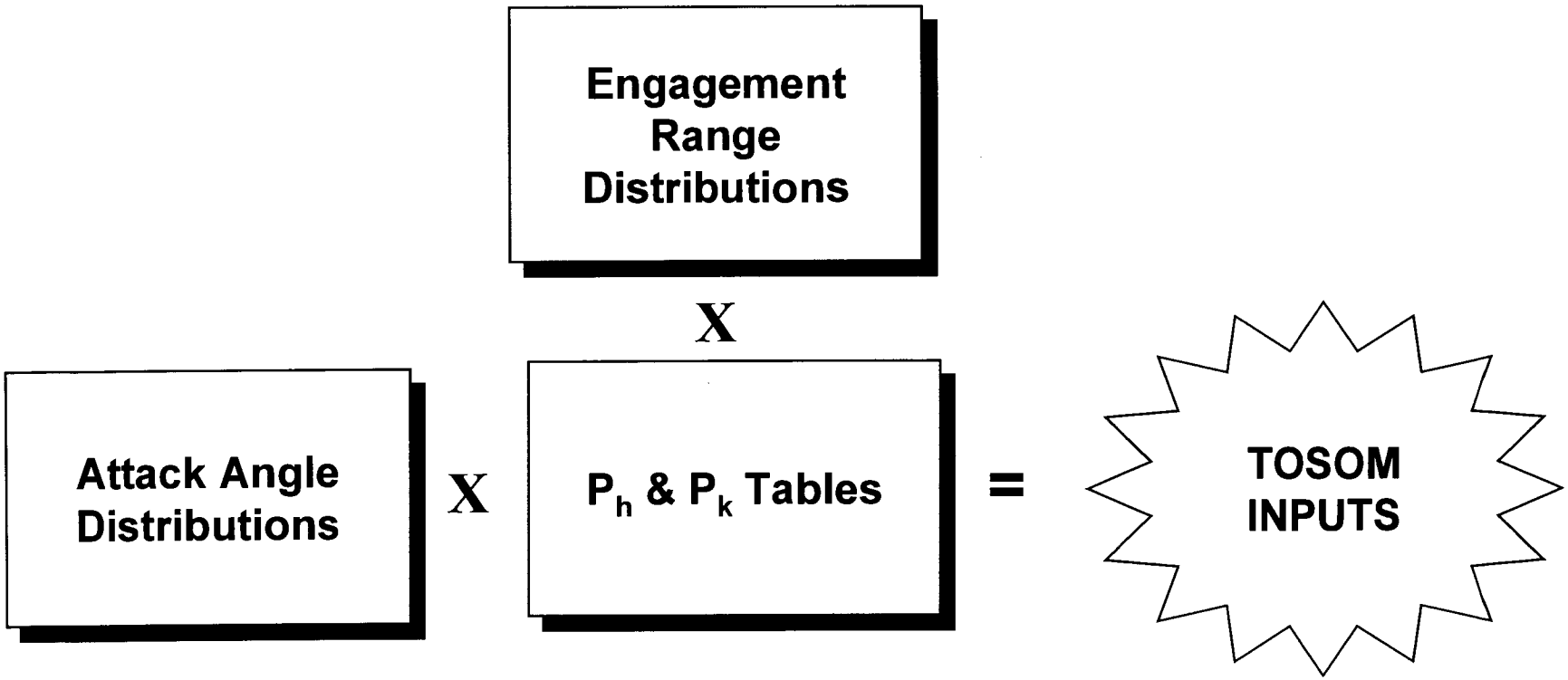
- Some Individual Unit Action (IUA) data sets available.
- Extensive data available from ELAN libraries.
- CASTFOREM data
- AMSAA data

IUA Data

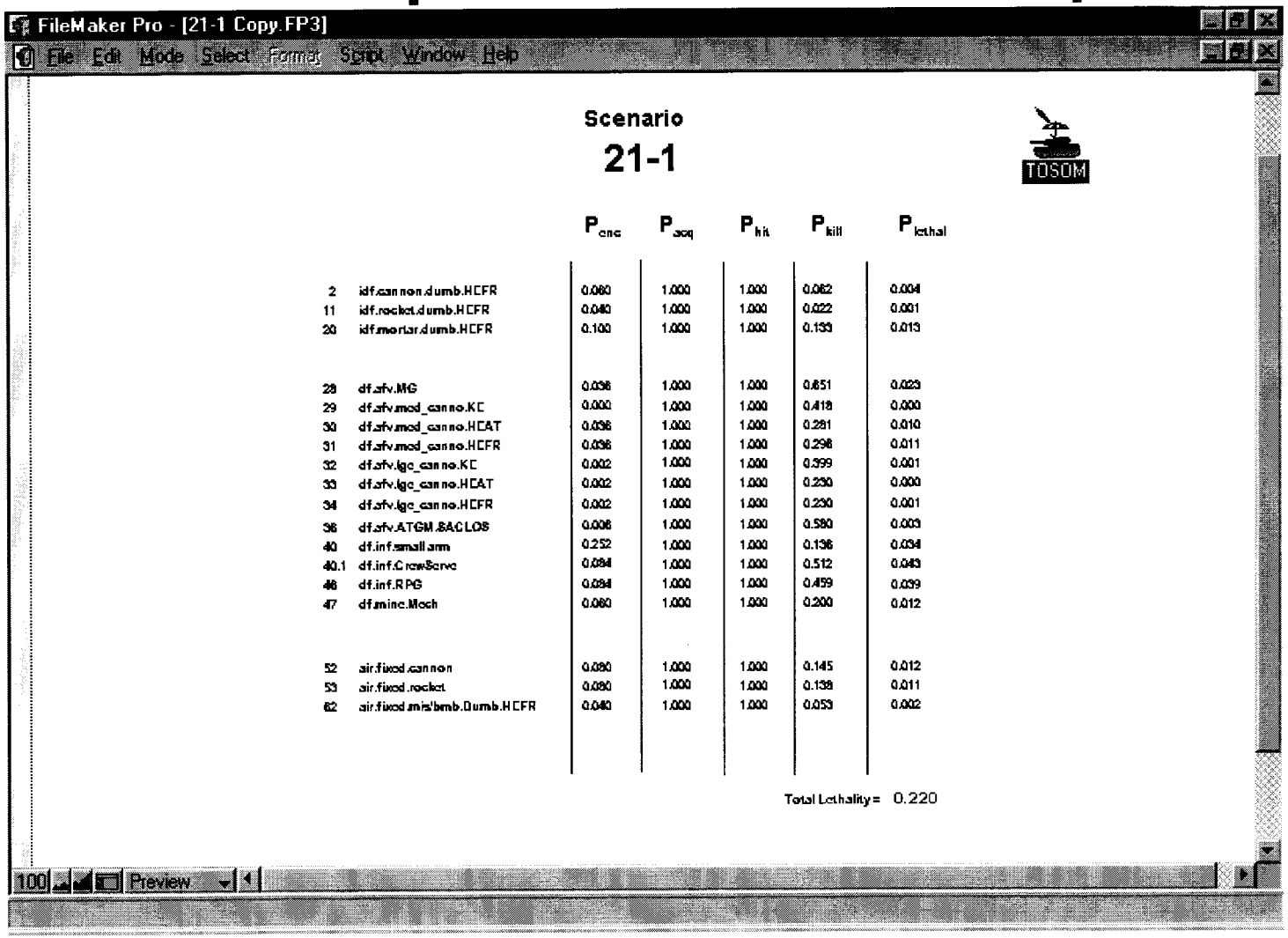
Range	HD=1 FE=2	Disp (ft)	Kill Type	0 Þ	30 Þ	60 Þ	90 Þ	120 Þ	150 Þ	180 Þ	Cardiod Avg.
250	1	1	1	0.976	0.976	0.976	0.980	0.980	0.980	0.976	0.976
250	1	1	2	0.984	0.988	0.988	0.984	0.984	0.984	0.980	0.984
250	1	1	3	0.984	0.988	0.988	0.984	0.984	0.984	0.980	0.984
250	1	1	4	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
250	1	2	1	0.972	0.972	0.972	0.972	0.976	0.976	0.972	0.972
250	1	2	2	0.980	0.984	0.984	0.980	0.980	0.984	0.980	0.980
250	1	2	3	0.980	0.984	0.984	0.980	0.980	0.984	0.980	0.980
250	1	2	4	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
250	1	3	1	0.972	0.969	0.972	0.972	0.976	0.972	0.972	0.972
250	1	3	2	0.980	0.980	0.984	0.980	0.984	0.980	0.980	0.980
250	1	3	3	0.980	0.980	0.984	0.980	0.984	0.980	0.980	0.980
250	1	3	4	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
250	1	4	1	0.972	0.969	0.969	0.972	0.972	0.972	0.972	0.972
250	1	4	2	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980
250	1	4	3	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980
250	1	4	4	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
250	1	5	1	0.972	0.969	0.969	0.969	0.972	0.972	0.972	0.969
250	1	5	2	0.980	0.980	0.980	0.976	0.980	0.980	0.980	0.976
250	1	5	3	0.980	0.980	0.980	0.976	0.980	0.980	0.980	0.976
250	1	5	4	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
250	1	6	1	0.972	0.969	0.969	0.969	0.972	0.972	0.972	0.969
250	1	6	2	0.980	0.976	0.980	0.976	0.980	0.980	0.980	0.976
250	1	6	3	0.980	0.976	0.980	0.976	0.980	0.980	0.980	0.976
250	1	6	4	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
250	1	7	1	0.972	0.969	0.969	0.969	0.972	0.972	0.972	0.969

Kill Type
1 = M kill
2 = F kill
3 = M or F kill
4 = K kill

Rolling Up the Data



Consequence Data Inputs



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Scenario

21-1

TOSOM

		P_{enc}	P_{acq}	P_{hit}	P_{kill}	P_{lethal}
2	idf.cannon.dumb.HCFR	0.060	1.000	1.000	0.062	0.004
11	idf.rocket.dumb.HCFR	0.040	1.000	1.000	0.022	0.001
20	idf.mortar.dumb.HCFR	0.100	1.000	1.000	0.133	0.013
28	df.afv.MG	0.036	1.000	1.000	0.651	0.023
29	df.afv.med_canno.KE	0.000	1.000	1.000	0.418	0.000
30	df.afv.med_canno.HEAT	0.036	1.000	1.000	0.281	0.010
31	df.afv.med_canno.HEFR	0.036	1.000	1.000	0.298	0.011
32	df.afv.lge_canno.KE	0.002	1.000	1.000	0.399	0.001
33	df.afv.lge_canno.HEAT	0.002	1.000	1.000	0.230	0.000
34	df.afv.lge_canno.HEFR	0.002	1.000	1.000	0.230	0.001
36	df.afv.ATGM.SACLOS	0.006	1.000	1.000	0.580	0.003
40	df.inf.small.arm	0.252	1.000	1.000	0.136	0.034
40.1	df.inf.CrewServe	0.084	1.000	1.000	0.512	0.043
46	df.inf.RPG	0.084	1.000	1.000	0.459	0.039
47	df.mine.Mech	0.060	1.000	1.000	0.200	0.012
52	air.fixed.cannon	0.060	1.000	1.000	0.145	0.012
53	air.fixed.rocket	0.060	1.000	1.000	0.138	0.011
62	air.fixed.mis/bmb.Dumb.HCFR	0.040	1.000	1.000	0.053	0.002

Total Lethality = 0.220

100 Preview

TOSOM

Parting Observations

- Current Scenarios do not incorporate many of the (advanced) postulated future threats.
- Surrogate data is widely used
- Many systems currently under study do not primarily rely on Armor for protection.

For More Information:

- TOSOM Website
- or contact:
  - TARDEC
    - Mr. Jack Reed (586)753-2562
    - Dr. Bill Jackson (586)574-6467

DEADLINE: March 14, 2003
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